TM-796
2960.0

Fermilab

TRANSPORT OF TEVATRON ENERGY PRIMARY PROTON BEAMS TO NEUTRINO AREA

R.Evans, T.Kirk
May 26, 1978

1. INTRODUCTION

This TM describes a scheme for transporting and splitting 1 TeV proton beams to Meson Lab, Neuhall and Muhall(the targeting area for the new Muon Beam[1]). The new MUO beam split, a further elaboration of scheme #1 TM-729[2], is characterized by electrostatic septa in the "notch" region of Enclosure C, Lambertson magnets in the G1 Manhole and superconducting dipoles in the G2 Manhole. The NØ beam to Neuhall is composed entirely of non-superconducting magnets. The pre-target triplet train is also conventional but elogated, spanning Neuhall. The proton beam dump between Enclosure C and G1 is not used(see Appendix A) and the N7 bypass beam is discontinued. Emphasis has been made in this design on maintaining existing beam lines and enclosure sizes to keep construction costs at a minimum.

The beam splitting for the Meson Area is developed in this report, but 1 TeV transport to the Proton Area, a more difficult problem, possibly coupled to the machine extraction channel itself, is not addressed here.

A discussion of the beams Enclosure by Enclosure follows. Element lists and beam envelopes are provided in Appendix C.

2. TRANSFER HALL(Z = 0.0-ft.)

The final 1 TeV configuration of the Transfer Hall is uncertain at this time. The present 400 GeV phase space at AØ was assumed in this report(see Appendix B) and two Transfer Hall quadrupoles MQ90 and MQ91 were simply scaled from 400 to 1000 GeV. The fields necessary would require these quadrupoles to be superconducting, but the purpose of this assumption was only to obtain a reasonable extracted beam with which to design the subsequent transport. The actual transport might be varied to accommodate other conditions in the Transfer Hall as they evolve.

3. ENCLOSURE B(Z = 370-ft. to Z = 800-ft.)

Enclosure B contains six electrostatic septum modules, each 10-ft. in length providing an electric field of 65 kv/cm. This septum station begins the Meson-Neutrino spolit. The vertically split beams exit the septa at 0.12 mrad each(see Appendix D). The entire septum string is sandwiched between two EPB dipoles which steer the beam vertically across the septum wires thus determining the split ratio. The downstream EPB dipole also bends the NO beam back to a Ø degree vertical angle. Following the splitting station both beams pass through an optical doublet consisting of four 3Q120 quadrupoles centered on the NØ beam. These provide the equivalent focussing of the present MQ100 and MQ101 quadrupoles. The spatial separation of the beams at these quadrupoles, and thus, the steering introduced in the Meson Area beam, is negligible.

4. ENCLOSURE C(Z = 962-ft. to Z = 1340-ft.)

After passing through a Lambertson radiation shield at the upstream Enclosure C wall, the beams which are now separated vertically by 1-inch enter a string of six Lambertson magnets at 8 kg followed by six C-type magnets at 12 kg(see Appendix E). Here the Meson Area beam, now 7.8 inches horizontally separated from the NØ beam and proceeding upwards at 0.24 mrad enters the West Bends. The 0.24 mrad vertical angle can be corrected with a trim magnet somewhere downstream of the C-type magnet string. The Meson beam is fully split from the NØ beam at this point and is not considered further in this report.

The NØ beam, after passing through the field free region of the Lambertson magnets and just East of the C-magnet field region, enters the MV100 string at Z = 1165.5 ft. which provides an up bend of 9.992 mrad. Seventy feet of Main Ring B2 type magnets are used at 15.62 kg. Alternatively, eight EPB dipoles could be used but then the bend point is moved downstream further from the present location. A single quadrupole, MQ103, is located immediately downstream of MV100.

The NØ-MUO horizontal splitting begins at Z = 1265-ft. with sixty feet of electrostatic septa at 60 kv/cm. The two split portions of the beam exit the septa at a relative horizontal angle of 0.22 mrad. The "notch" region must be excavated from Z = 1320-ft. to accommodate this splitting station; the existing East wall of the Enclosure might be maintained as a radiation shield between the septa and the superconducting West Bends to Meson Area.

5. G1 MANHOLE(Z = 1630-ft. to Z = 1707.5 ft.)

A set of five, 10-ft. long Lambertson septum magnets are located in the G1 Manhole, replacing an existing quadrupole doublet and drift space. NØ passes through the field free hole and MUO is bent down in the magnet gap by 2.70 mrad. The beams are separated horizontally by 0.93 inches at the entrance to the Lambertson magnets. They are separated by 1.07 inches horizontally and 0.87 inches vertically at the end of the Lambertson string.

6. G2 MANHOLE (Z = 2225-Ft. to Z = 2380-ft.)

The MUO line enters the G2 Manhole 17.8 inches below NØ, 44.4 inches above the floor and 2.44 inches East of NØ. At this point it is bent 8.55 mrad downward and 30 mrad horizontally to aim it midway between Neuhall and the Target Service Building(TSB). For 1000 GeV this bend could be accomplished with four 22 foot superconducting dipoles run at a field of 38.51 kg. The magnets are skewed at an angle of 16.035 degrees with respect to horizontal to accomplish the horizontal and vertical components of the bend simultaneously. MUO is thereby transmitted at a downward angle of 1.260 mrad to arrive at Muhall approximately 12-feet below local ground level. A vertical dipole upstream of the Muon production target is used to bend MUO back up to horizontal. The G2 Manhole must be extended northward by about 100 feet to accommodate the new bending station for MUO.

MUO and NØ beams pass through separate conventional quadrupole doublets in G2. The MUØ beam drifts to the Muhall target area alongside existing Enclosure 100 where it is focussed onto the production target for the Muon Beam. A buried beam pipe placed alongside the present Neutrino earth berm, together with five quadrupole enclosures necessary for MUO focussing between the G2 Manhole and Muhall should properly transport the beam to the Muon production Target. (See section 9 et.seq. of this report.)

7. G3 MANHOLE (Z = 2865-ft. to Z = 2925-ft.)

The G3 Manhole contains another conventional quadrupole doublet for NØ focussing. Horizontal trim magnets (EPB dipoles) here and in the G2 Manhole correct for the 0.11 mrad horizontal angle introduced by the septa in Enclosure C. The beam thus exits G3 at X = -0.6699 Ft.* with Ø degree horizontal angle.

8. NEUHALL (Z = 3124-ft. to Z = 3484-ft.)

The downstream MV100 string consisting of seventy-feet of B2 type dipoles is located at the Neuhall entrance. The NØ beam is deflected downward to Ø degrees and directed into the pre-target quadrupole triplet. This triplet consists of six conventional 3Q120 quadrupoles and focusses the beam unto the target at Z = 3484.110 ft. with a one-mm spot. There is ample room for the usual complement of trim magnets in Neuhall with the demise of the N7 bypass beam.

9. MUØ TRANSPORT FROM MUBEND TO 2T1 TARGET

Five small quadrupole enclosures, each roughly 25-ft. long, are required for the MUØ transport from the G2 Manhole to the target, 2T1. The beam drifts from G2 to the first quadrupole enclosure E1 which contains a single focussing quadrupole. A defocussing quadrupole in E2 just downstream of E1 completes this doublet in the vicenity of Neuhall. E1 is centered on Z = 3669 ft. and E2 is centered on Z = 3723 ft. Enclosure E2 also contains a 10-foot EPB dipole which bends the beam up from -1.252 mrad to Ø mrad. The beam thus travels from this point to the target at a uniform depth of 733 ft. (approximately 12 feet below local ground level). The three remaining enclosures E3, E4,E5 comprise a triplet of quadrupoles roughly 300 ft. in length similar to that in Neuhall. Trim magnets may be placed in E1 and E 3 which contain only single quadrupoles. A beam envelope from a typical quadrupole tune is given in Appendix C.

* It should be noted that in the Switchyard coordinate system positive X-axis points West. The Neutrino coordinate system is used in this report and is consistent with the TRANSPORT[3] convention. The Y-axis point up and the Z-axis points along the beam line making a right handed coordinate system.

REFERENCES

1. EVANS, R. et al., "Design Study for a High Energy Muon Beam," TM-754, November, 1977.

2. APPEL, J.A. and McCarthy, J.D., "New Muon Laboratory, Part 1" TM-729, May 6, 1977.

3. BROWN, K.A. et al.,"Transport, a Computer Program for Designing Charged Particle Beam Transport Systems," Fermilab-91, March, 1974.

Appendix B: Phase space at Aϕ.

The following phase space, measured at 400 GeV, was used for the transport designs. (Source: R. Dixon, private communication)

at Aϕ($z = 0'$):

$$\beta_x = 100\,m = 10^5\,mm$$

$$\alpha_x = .43$$

$$\pi\epsilon_x = \pi(.14)\,mm\cdot mrad = \pi(.14 \times 10^{-3})\,mm\cdot rad$$

$$\beta_y = 72\,m = 7.2 \times 10^4\,mm$$

$$\alpha_y = .70$$

$$\pi\epsilon_y = \pi(.08)\,mm\cdot mrad = \pi(.08 \times 10^{-3})\,mm\cdot rad$$

$$\frac{\Delta P}{P} = .1\% \; ; \; P = 400\,GeV/c \; ; \text{ slow spill.}$$

Conversion to TRANSPORT parameters:

$$\begin{pmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{pmatrix} = \epsilon_x \begin{pmatrix} \beta_x & -\alpha_x \\ -\alpha_x & \gamma_x \end{pmatrix} \; ; \; \gamma = \frac{1+\alpha^2}{\beta}$$ (source: SLAC-91, pg. A-39)

thus

$$\sigma_{11} = \epsilon_x \beta_x = 14.$$

$$\sigma_{21} = \sigma_{12} = -\epsilon_x \alpha_x = -6.02 \times 10^{-5}$$

$$\gamma_x = 1.1849 \times 10^{-5}$$

$$\sigma_{22} = \epsilon_x \gamma_x = 1.659 \times 10^{-9}$$

similarly

$$\sigma_{33} = \epsilon_y \beta_y = 5.76$$

$$\sigma_{43} = \sigma_{34} = -\epsilon_y \alpha_y = -5.6 \times 10^{-5}$$

$$\gamma_y = 2.069 \times 10^{-5}$$

$$\sigma_{44} = \epsilon_y \gamma_y = 1.655 \times 10^{-9}$$

units for the above are in mm and radians.

Beam size: (Source: TRANSPORT manual, pg 33-35)

$\Delta x = \sqrt{\sigma_{11}} = 3.74$ mm $= .147''$

$\Delta \theta_x = \sqrt{\sigma_{22}} = .04073$ mrad

$\Delta y = \sqrt{\sigma_{33}} = 2.4$ mm $= .094''$

$\Delta \theta_y = \sqrt{\sigma_{44}} = .04068$ mrad

Correlations:

$$r(ij) = \frac{\sigma(ij)}{\sqrt{\sigma(ii)\,\sigma(jj)}}$$

$r(12) = -.395$

$r(34) = -.574$

APPENDIX C

UPSTREAM COORDINATES

ELEMENT	TYPE	STRENGTH	BEAM	Z (Ft.)	X(Ft.)	Y(Ft.)	THX (mr)	THY (mr)
MQ90		10kg/in. x 10 ft.		133.25	-.67	725.144	0.0	0.0
MQ91		-6.475kg/in. x 10 ft.		172.124	-.67	725.144	0.0	0.0
MVT100	5-1.5-120	variable x 10 ft.		538.0	-.67	725.144	0.0	0.0
ESME-1	ES SEPTUM	65kv/cm x 10 ft.	Meson	597.497	-.67	725.144	0.0	0.0
			NØ		-.67	725.144	0.0	0.0
ESME-2	ES SEPTUM	65kv/cm x 10 ft.	Meson	609.997	-.67	725.1441	0.0	0.02
			NØ		-.67	725.1439	0.0	-0.02
ESME-3	"	"	Meson	622.497	-.67	725.1445	0.0	0.04
			NØ		-.67	725.1434	0.0	-0.04
ESME-4	"	"	Meson	634.997	-.67	725.1452	0.0	0.06
			NØ		-.67	725.1428	0.0	-0.06
ESME-5	"	"	Meson	647.497	-.67	725.1461	0.0	0.08
			NØ		-.67	725.1419	0.0	-0.08
ESME-6	"	"	Meson	659.997	-.67	725.1473	0.0	0.10
			NØ		-.67	725.1407	0.0	-0.10
MVT101	5-1.5-120	1.3164kg. x 10 ft.	Meson	672.497	-.67	725.1487	0.0	0.241
			NØ		-.67	725.1393	0.0	0.0
MQ100-1	3Q120	3.61674kg/in. x 10 ft.	Meson	694.997	-.67	725.1535	0.0	0.241
			NØ		-.67	725.1387	0.0	0.0
MQ100-2	"	"	Meson	706.997	-.67	725.1564	0.0	0.241
			NØ		-.67	725.1387	0.0	0.0
MQ101-1	"	-3.87003kg/in. x 10 ft.	Meson	744.997	-.67	725.1655	0.0	0.241
			NØ		-.67	725.1387	0.0	0.0
MQ101-2	"	"	Meson	769.997	-.67	725.1715	0.0	0.241
			NØ		-.67	725.1387	0.0	0.0
LAMB-1	LAMBERTSON	8.0kg x 10 ft.	Meson	969.347	-.67	725.2195	0.0	0.241
			NØ		-.67	725.1387	0.0	0.0
LAMB-2	"	"	Meson	980.347	-.6656	725.2221	0.731	0.241
			NØ		-.67	725.1387	0.0	0.0
LAMB-3	"	"	Meson	991.347	-.6532	725.2248	1.462	0.241
			NØ		-.67	725.1387	0.0	0.0
LAMB-4	"	"	Meson	1002.347	-.6327	725.2274	2.193	0.241
			NØ		-.67	725.1387	0.0	0.0
LAMB-5	"	"	Meson	1013.3469	-.6042	725.2301	2.924	0.241
			NØ		-.67	725.1387	0.0	0.0
LAMB-6	"	"	Meson	1024.3469	-.5677	725.2327	3.655	0.241
			NØ		-.67	725.1387	0.0	0.0
CMAG-1	S1B120	12.kg x 10 ft.	Meson	1035.8468	-.5209	725.2355	4.386	0.241
			NØ		-.67	725.1387	0.0	0.0
CMAG-2	S1B120	12.kg x 10 ft.	Meson	1046.8466	-.4660	725.2381	5.482	0.241
			NØ		-.67	725.1387	0.0	0.0

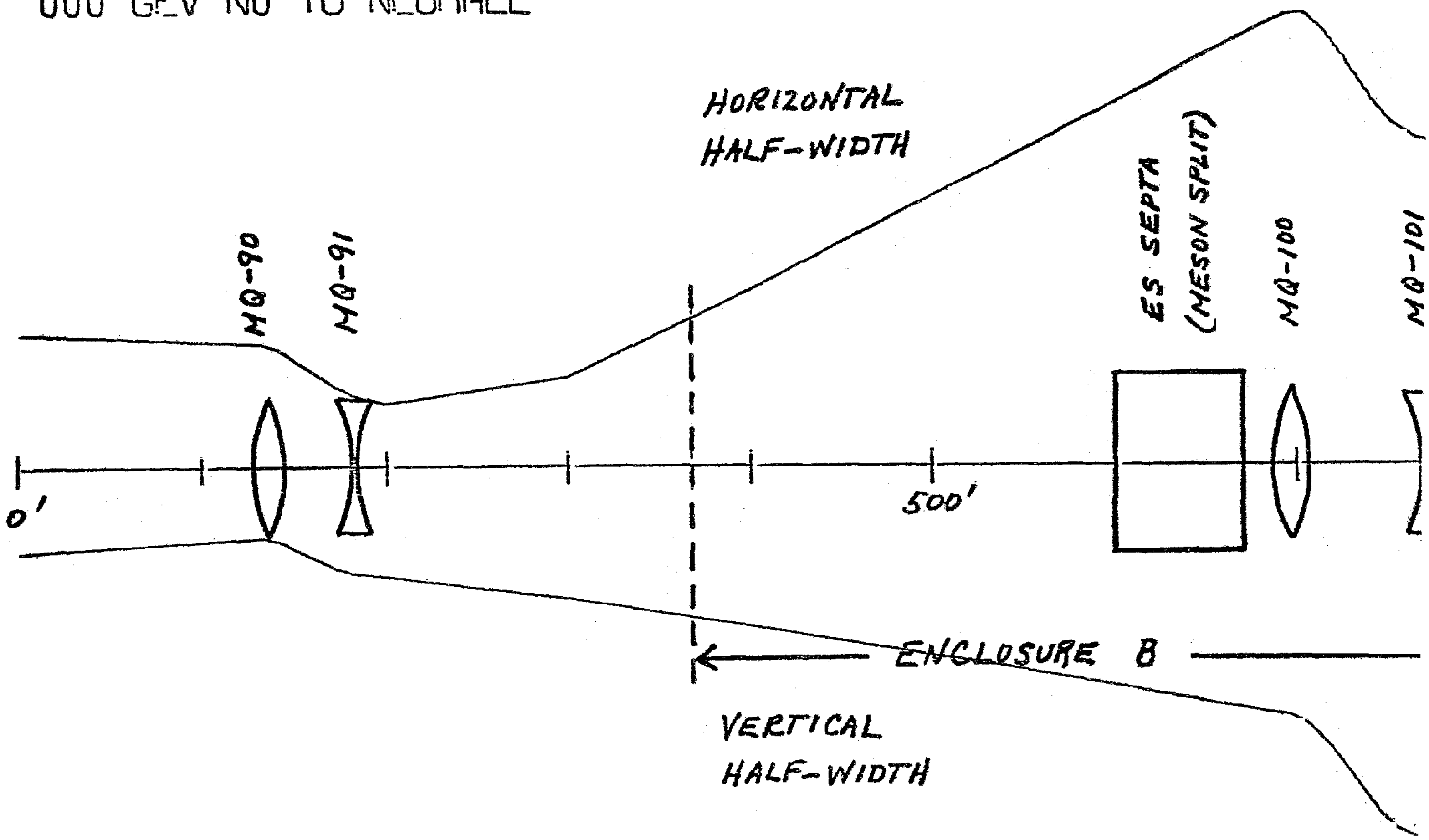
ELEMENT	TYPE	STRENGTH	BEAM	Z (Ft.)	X(Ft.)	Y (Ft.)	THX (mr)	THY (mr)
CMAG-3	S1B120	12.kg x 10 ft.	Meson	1057.8465	-.3992	725.2408	6.579	0.241
			NØ		-.67	725.1387	0.0	0.0
CMAG-4	"	"	Meson	1068.8462	-.3202	725.2434	7.675	0.241
			NØ		-.67	725.1387	0.0	0.0
CMAG-5	"	"	Meson	1079.8458	-.2292	725.2461	8.772	0.241
			NØ		-.67	725.1387	0.0	0.0
CMAG-6	"	"	Meson	1090.8453	-.1261	725.2487	9.868	0.241
			NØ		-.67	725.1387	0.0	0.0
MV100-1	4-2-120	15.623kg x 10 ft.	Meson	1156.5	+.56	725.2628	11.33	0.241
			NØ	1156.5	-.67	725.1387	0.0	0.0
MV100-2	4-2-240	15.623kg x 20 ft.	NØ	1167.5	-.67	725.1473	0.0	1.427
MV100-3	"	"	NØ	1188.5	-.67	725.2087	0.0	4.282
MV100-4	"	"	NØ	1209.5	-.67	725.3300	0.0	7.137
MHT100	5-1.5-120	variable x 10 ft.	NØ	1230.5	-.67	725.5113	0.0	9.992
MQ103	3Q120	2.05124kg/in. x 10 ft.	NØ	1246.009	-.67	725.6663	0.0	9.992
ESMU-1	ES SEPTUM	60kv/cm x 10 ft.	NØ	1264.99	-.67	725.9559	0.0	9.992
			MUO		-.67	725.9559	0.0	9.992
ESMU-2	"	"	NØ	1275.99	-.6699	725.9659	0.018	9.992
			MUO		-.6701	725.9659	-0.018	9.992
ESMU-3	"	"	NØ	1286.986	-.6696	726.0785	0.037	9.992
			MUO		-.6704	726.0785	-0.037	9.992
ESMU-4	"	"	NØ	1297.9854	-.6691	726.1858	0.055	9.992
			MUO		-.6709	726.1858	-0.055	9.992
ESMU-5	"	"	NØ	1308.9849	-.6684	726.2957	0.073	9.992
			MUO		-.6716	726.2957	-0.073	9.992
ESMU-6	"	"	NØ	1319.9843	-.6674	726.4056	0.091	9.992
			MUO		-.6726	726.4056	-0.091	9.992
MULMB-1	LAMBERTSON	5.906kg x 10 ft.	NØ	1650.4869	-.6313	729.7085	0.110	9.992
			MUO		-.7087	729.7085	-0.110	9.992
MULMB-2	"	"	NØ	1661.4863	-.6301	729.8184	0.110	9.992
			MUO		-.7099	729.8152	-0.110	9.453
MULMB-3	"	"	NØ	1672.4858	-.6289	729.9283	0.110	9.992
			MUO		-.7111	729.9159	-0.110	8.913
MULMB-4	"	"	NØ	1683.4852	-.6277	730.0383	0.110	9.992
			MUO		-.7123	730.0107	-0.110	8.373
MULMB-5	"	"	NØ	1694.4847	-.6265	730.1482	0.110	9.992
			MUO		-.7135	730.0996	-0.110	7.834

ELEMENT	TYPE	STRENGTH	BEAM	UPSTREAM COORDINATES Z(ft.)	X(ft.)	Y(ft.)	THX(mr)	THY(mr)
MQ120-1	3Q120	-4.06449kg/in. x 10 ft.	NØ	2227.4581	-0.5680	735.4744	0.110	9.992
MUQ-1	"	-3.62750kg/in. x 10 ft.	MUO	2227.4709	-0.7720	733.9904	-0.110	7.294
MQ120-2	"	-4.06449kg/ "	NØ	2239.2076	-0.5667	735.5918	0.110	9.992
MUQ-2	"	-3.62750kg/ "	MUO	2239.2206	-0.7733	734.0761	-0.110	7.294
MHTG2	5-1.5-120	2.9972kg x 10 ft.	NØ	2250.9670	-0.5654	735.7092	0.110	9.992
			MUO		-0.7746	734.1617	-0.110	7.294
MQ121-1	3Q120	3.55519kg/in. x 10 ft.	NO	2262.7064	-0.5660	735.8267	-0.164	9.992
MUQ-3	"	3.8330 kg/ "	MUO	2262.7199	-0.7758	734.2475	-0.110	7.294
MQ121-2	"	3.55519kg/ "	NØ	2274.4558	-0.5679	735.9441	-0.164	9.992
MUO-4	"	3.8330 kg/ "	MUO	2274.4696	-0.7771	734.3332	-0.110	7.294
MUBND-1	SC	38.50854 kg/ x 22 ft.	NØ	2287.4693	-0.5700	736.0741	-0.164	9.992
			MUO	2287.4693	-0.7786	734.4280	-0.110	7.294
MUBND-2	"	"	NØ	2310.4685	-0.5738	736.3039	-0.164	9.992
		"	MUØ	2310.4686	-0.8704	734.5702	-7.549	5.156
MUBND-3	"	"	NØ	2333.4664	-0.5775	736.5337	-0.164	9.992
		"	MUO	2333.4669	-1.1333	734.6631	-14.989	3.017
MUBND-4	"	"	NØ	2356.4611	-0.5813	736.7635	-0.164	9.992
			MUO	2356.4627	-1.5673	734.7068	-22.428	0.878
MQ130-1	3Q120	3.22537kg/in. x 10 ft.	NØ	2866.9262	-0.6652	741.8649	-0.164	9.992
			MUO	2866.9262	-16.7322	734.0871	-29.868	-1.260
MQ130-2	"	"	NØ	2878.6756	-0.6672	741.9823	-0.164	9.992
			MUO	2878.6756	-17.0831	734.0723	-29.868	-1.260
MHTG3	5-1.5-120	1.7979kg x 10 ft.	NØ	2890.4250	-0.6691	742.0997	-0.164	9.992
			MUO	2890.4250	-17.4340	734.0575	-29.868	-1.260
MQ131-1	3Q120	-2.85674kg/in. x 10 ft.	NØ	2902.1745	-0.6699	742.2172	0.0	9.992
			MUO	2902.1745	-17.7850	734.0427	-29.868	-1.260
MQ131-2	"	"	NØ	2913.9239	-0.6699	742.3346	0.0	9.992
			MUO	2913.9239	-18.1359	734.0279	-29.868	-1.260
MV100-5	4-2-120	15.623kg x 10 ft.	NØ	3133.4129	-0.6699	744.5280	0.0	9.992
			MUO	3133.4129	-24.6916	733.7514	-29.868	-1.260
MV100-6	4-2.240	15.623kg x 20 ft.	NØ	3144.4125	-0.6699	744.6294	0.0	8.565
MV100-7	"	"	NØ	3165.4120	-0.6699	744.7778	0.0	5.710
MV100-8	"	"	NØ	3186.4118	-0.6699	744.8664	0.0	2.855
ODN1	3Q120	-3.40157kg/in. x 10 ft.	NØ	3208.4117	-0.6699	744.8949	0.0	0.0
ODN2	"	"	NØ	3219.9117	-0.6699	744.8949	0.0	0.0
OFN1	"	4.69667kg/in. x 10 ft.	NØ	3320.9117	-0.6699	744.8949	0.0	0.0
OFN2	"	"	NØ	3332.4117	-0.6699	744.8949	0.0	0.0
ODN3	"	-3.88164kg/in. x 10 ft.	NØ	3433.4117	-0.6699	744.8949	0.0	0.0
ODN4	"	"	NØ	3444.9117	-0.6699	744.8949	0.0	0.0
OT2	TARGET		NØ	3484.1100	-0.6699	744.8949	0.0	0.0
			MUO	3484.1100	-35.1662	733.3095	-29.868	-1.260

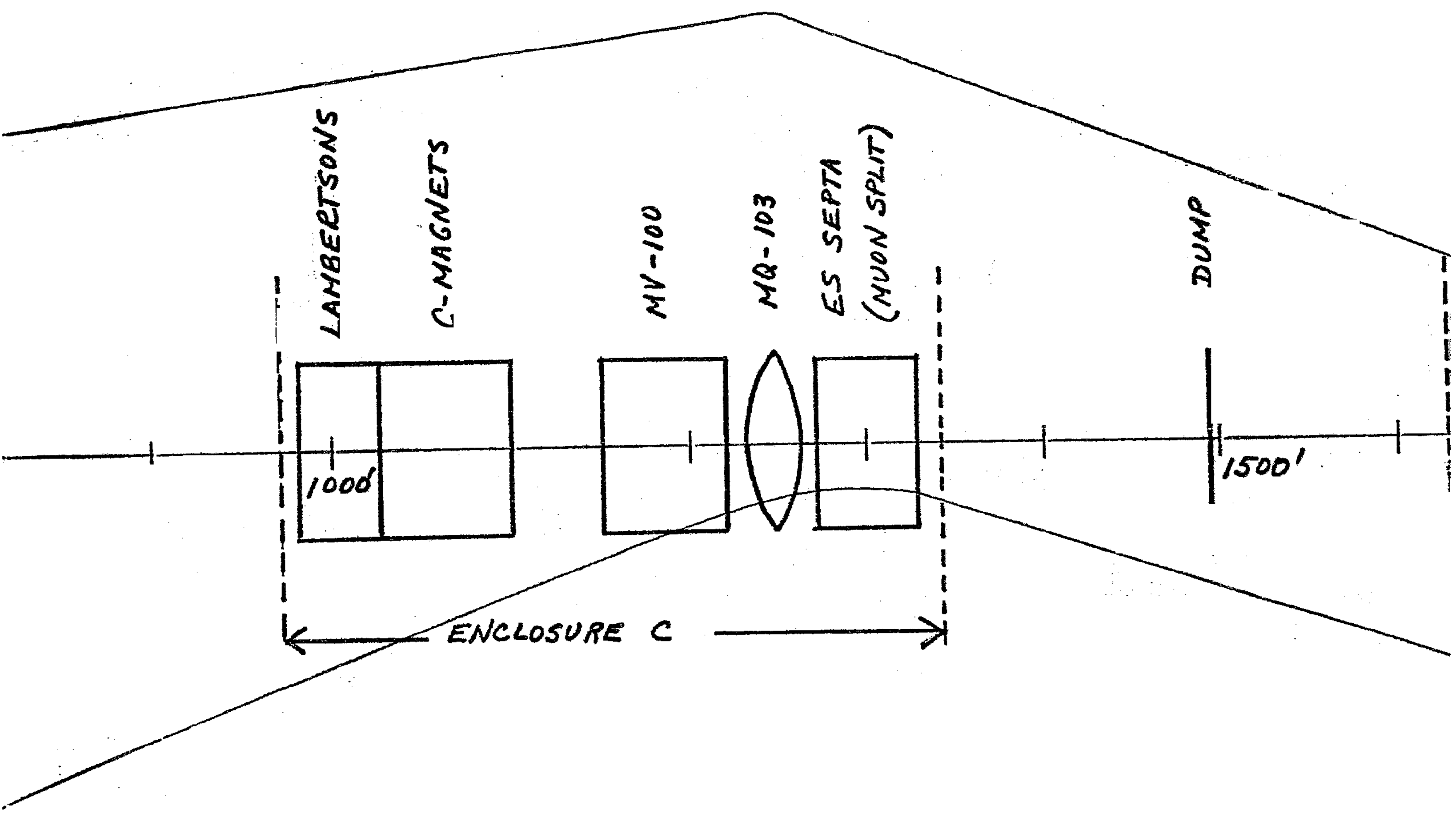
MUØ LINE FROM MUBND TO TARGET

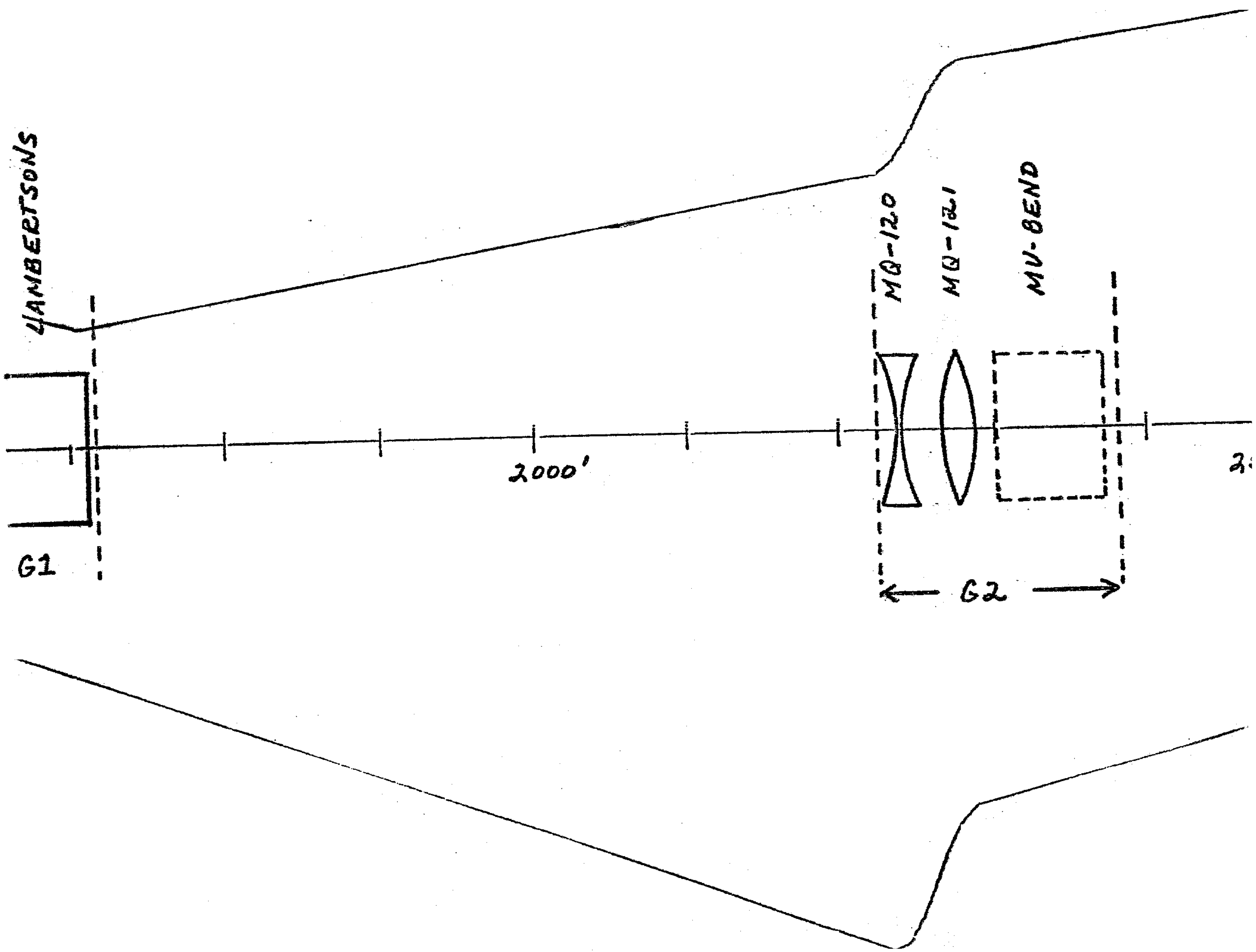
ELEMENT	TYPE	STRENGTH	BEAM	UPSTREAM COORDINATES Z(ft.)	X(ft.)	Y(ft.)	THX(mr)	THY(mr)
M Q5	3Q120	3.6612kg/in. x 10 ft.	MUØ	3658.8827	-40.4002	733.0879	-29.868	-1.260
M Q6	"	-3.700kg/ in. x 10 ft.	MUØ	3712.8586	-42.0129	733.0198	-29.868	-1.260
M P	5-1.5-120	13.81036kg/ x 10 ft.	"	3724.8532	-42.3713	733.0047	-29.868	-1.260
M D1	3Q120	-3.0265kg/in. x 10 ft.	"	4480.5160	-64.9497	732.9995	-29.868	+0.001
M F1	"	3.7852kg/in. x 10 ft.	"	4587.4683	-68.1453	732.9996	-29.868	-0.001
M F2	"	"	"	4599.4629	-68.5037	732.9997	-29.868	-0.001
M D2	"	-3.0615kg/in. x 10 ft.	"	4700.4178	-71.5202	732.9998	-29.868	-0.001
M D3	"	"	"	4712.4125	-71.8785	732.9998	-29.868	-0.001
2T1	TARGET		"	4850.3510	-76.0000	733.0000	-29.868	-0.001

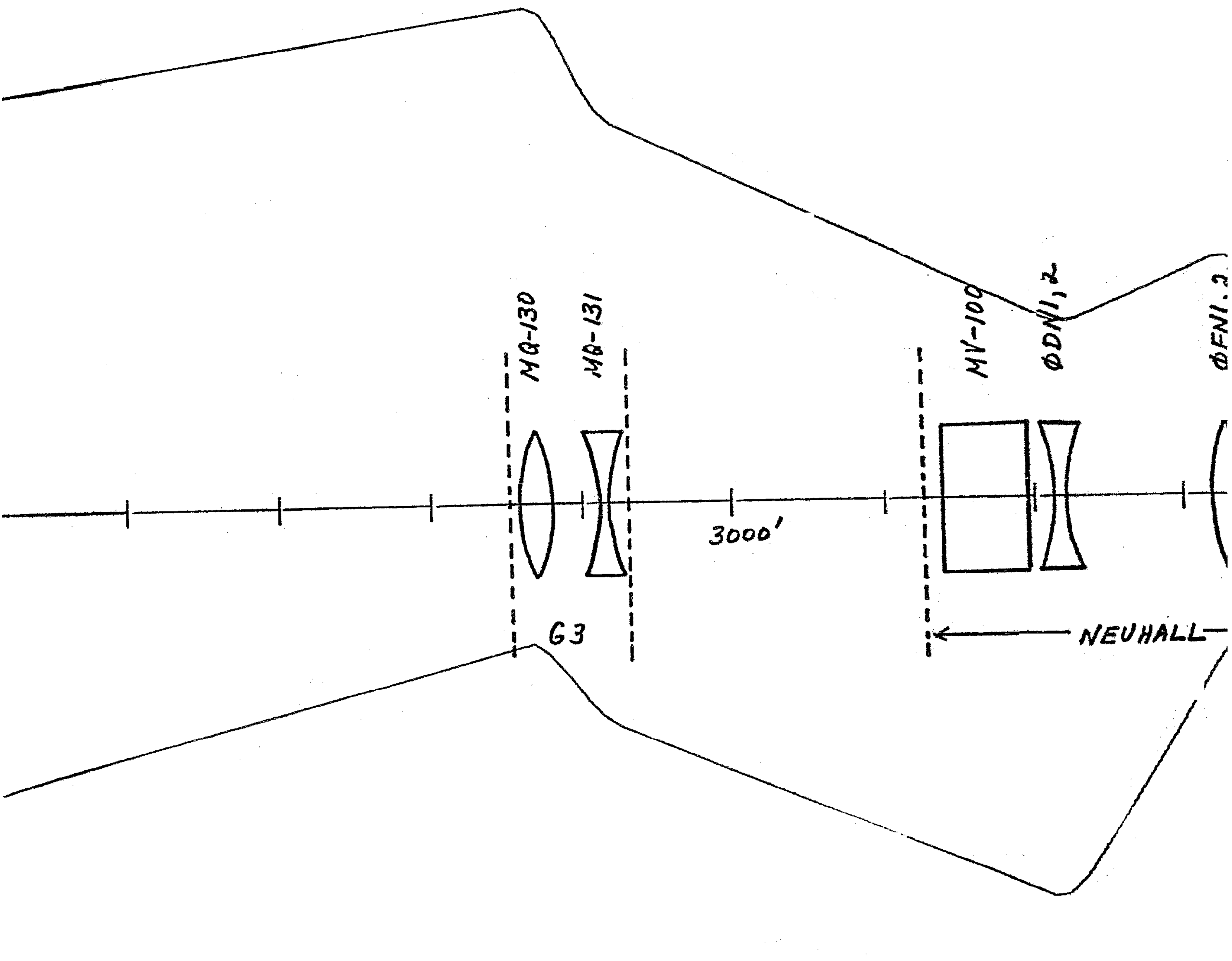
000 GEV NO TO NEUHALL

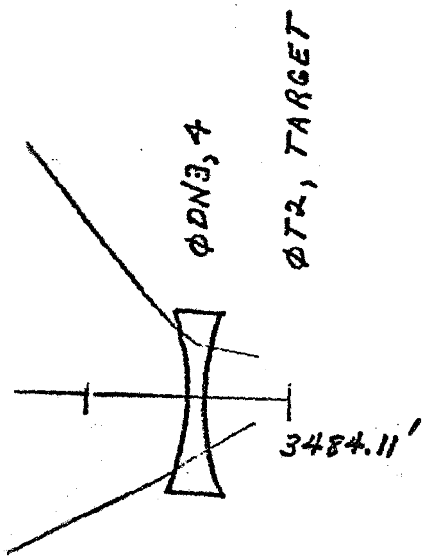


HORZ SCALE 1" = 100.0 FEET
VERT SCALE 1" = .20 INCHES
TIC SPACING = 100.0 FEET


LAMBERTSONS
C-MAGNETS
MV-100
MQ-103
ES SEPTA
(MUON SPLIT)
DUMP
1000'
1500'
ENCLOSURE C

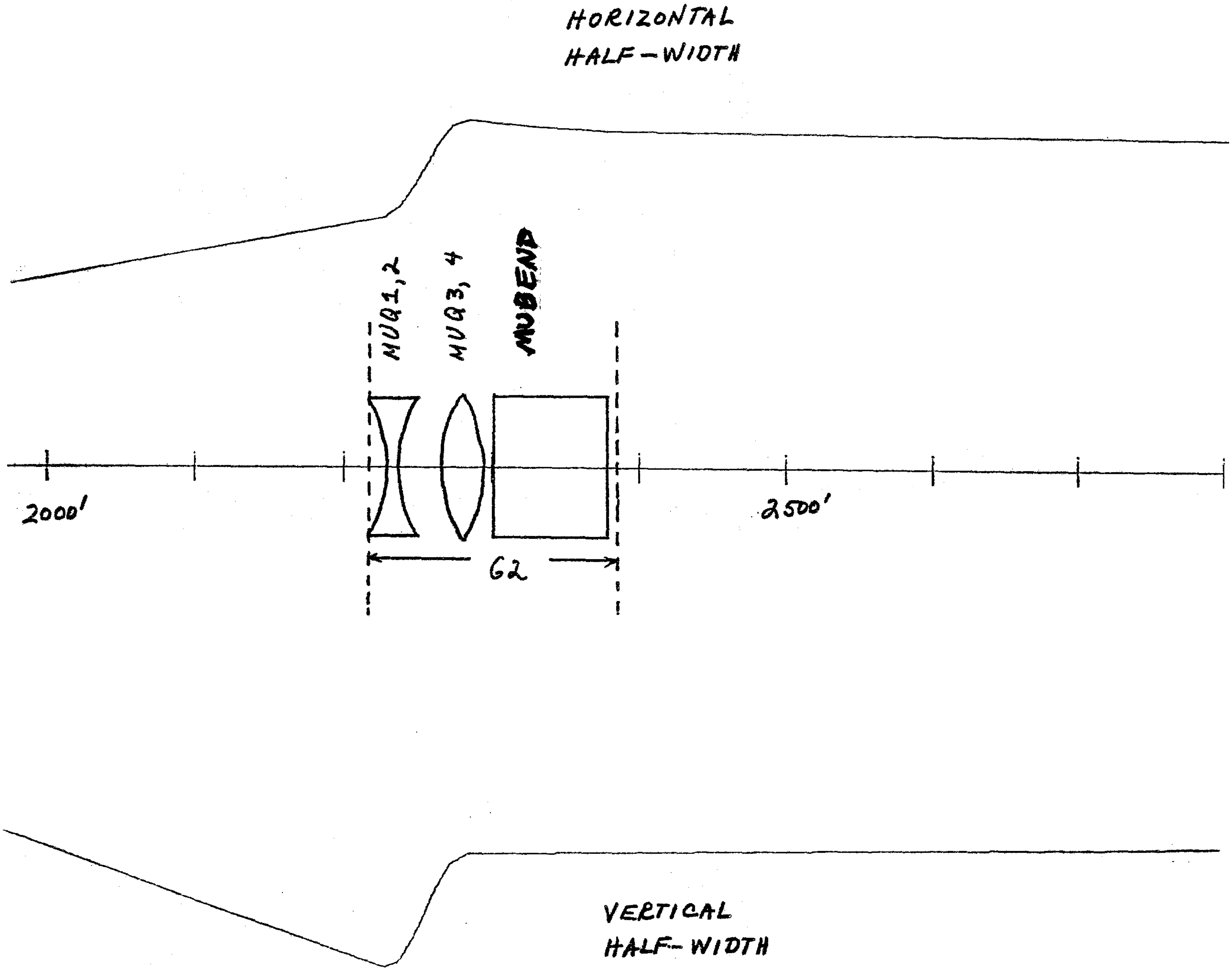

LAMBERTSONS
MQ-120
MQ-121
MV-BEND
2000'
G1
G2


MQ-130
MQ-131
MV-100
ΦDNI1,2
ΦFNI.2
3000'
G3
NEUHALL


ØDN3,4
ØT2, TARGET
3484.11'

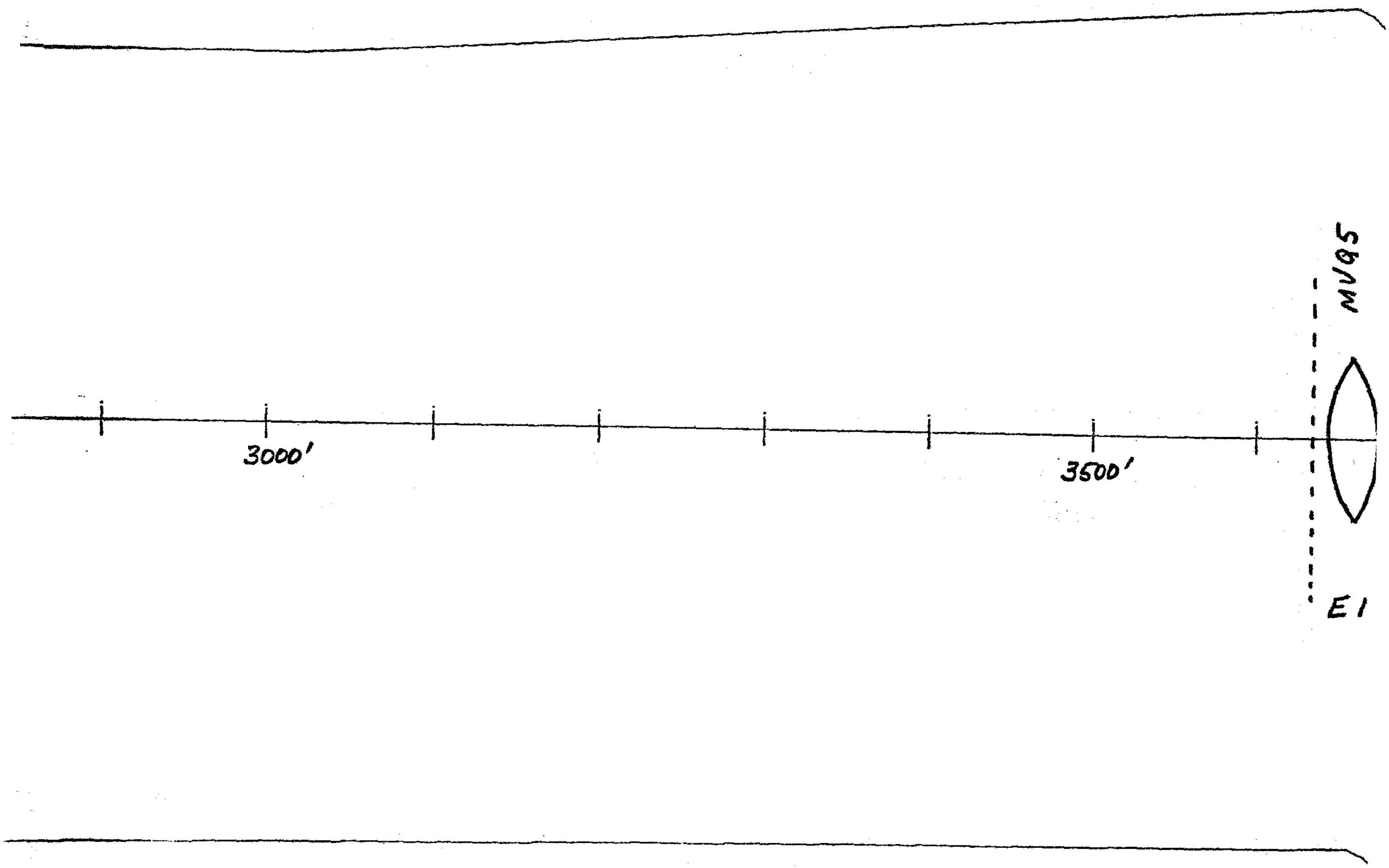
1000 GeV MUφ LINE

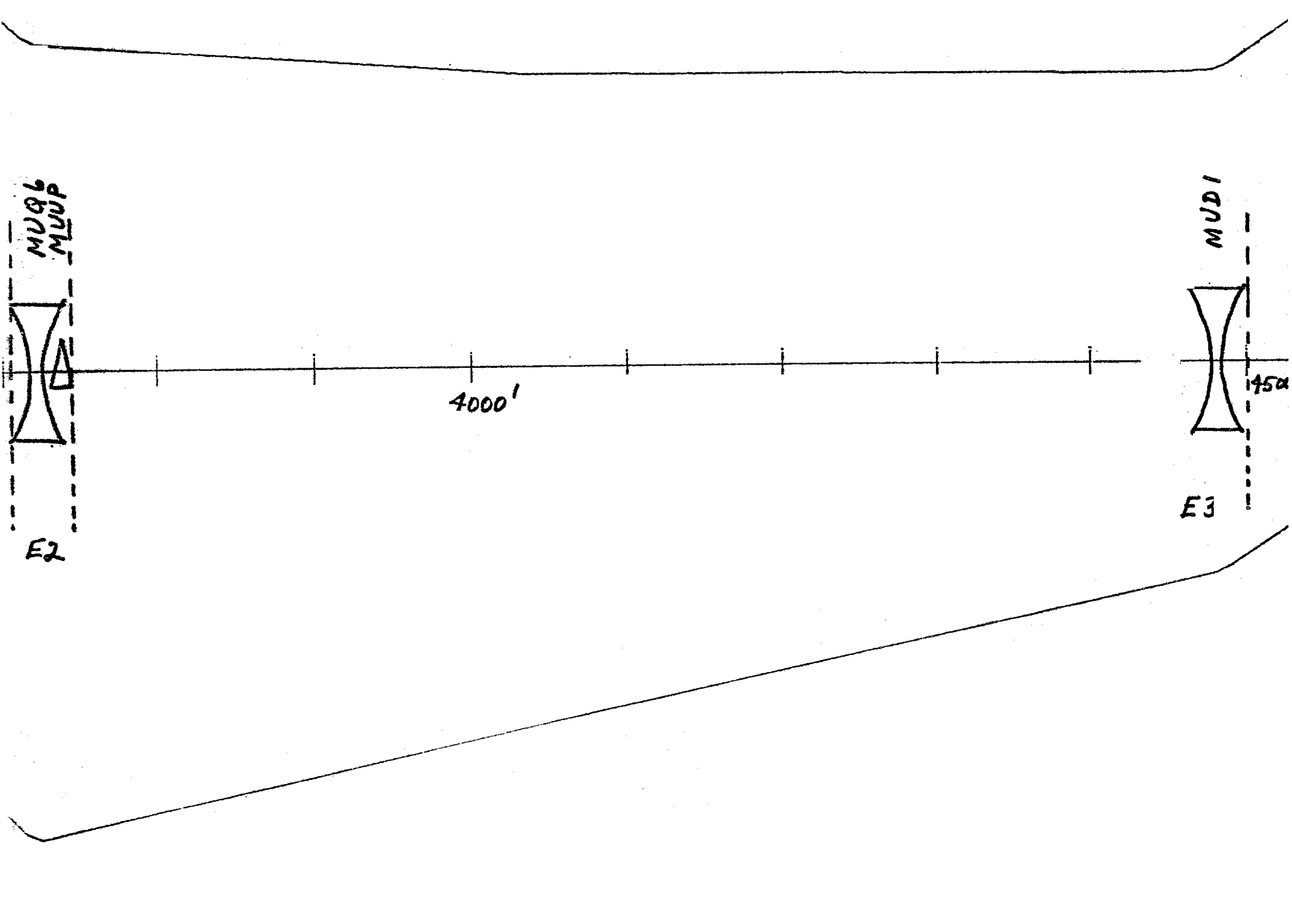
FROM MUBEND TO 2TI TARGET

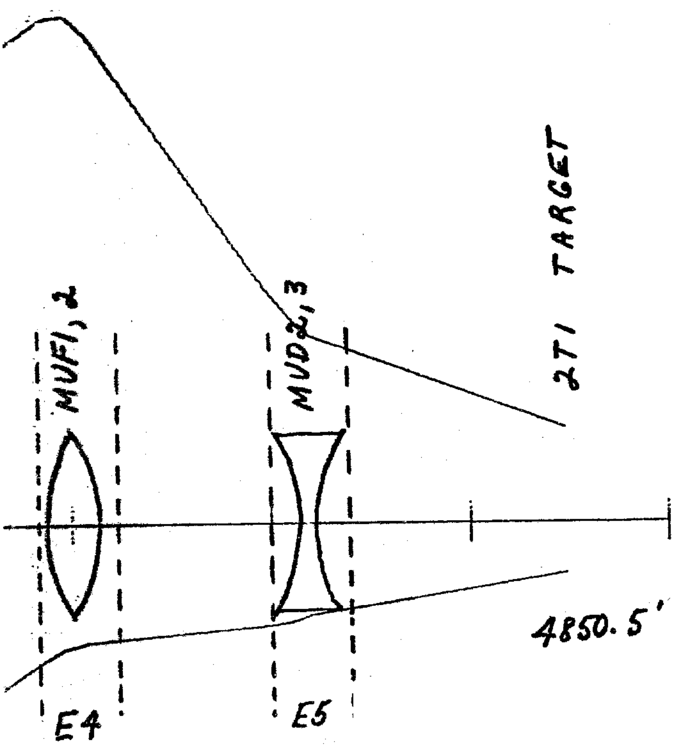


HORZ. SCALE 1" = 100 FEET

VERT. SCALE 1" = .2 INCHES


3000'
3500'
MVQ5
E1


MUQ6
MUUP
E2
4000'
MUD1
E3
450


MUF1,2
MUD2,3
2T1 TARGET
4850.5'
E4
E5

Appendix D: Electrostatic Septa

$$\Delta P = \Delta P_{\perp} = F\Delta t = eE\Delta t$$

$$\ell = c\Delta t$$

$$\therefore \; P_{\perp} = \frac{eE\ell}{c}$$

e.g. $E = 60$ kV/cm

$\ell = 60' = 1828.8$ cm

$$P_{\perp} = \frac{e}{c}\left(6\times10^{4}\frac{V}{cm}\right)(1828.8\,cm) = 1.097\times10^{8}\frac{eV}{c} = .1097\frac{GeV}{c}$$

Hence at 1000 GeV/c,

$\theta = .1097$ mrad for each portion of split beam.

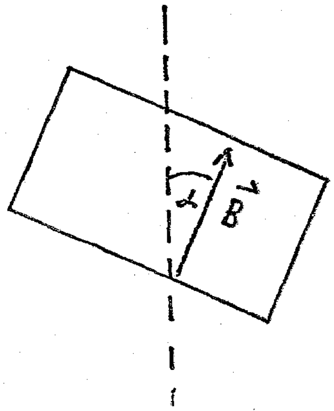
"Equivalent dipole" (necessary for TRANSPORT):

Each 10′ septum bends .01828 mrad.

$$.01828\times10^{-3} = \frac{.03}{1000}B\,(3.048\,m)$$

$$\therefore \; B = .2\ KG$$

MUBEND



$\theta_H = 33.5$ mrad

$\theta_V = 8.55$ mrad

$\theta_H = .03\ B\cos\alpha\,(26.82\,m) = 33.5$

$\theta_V = .03\ B\sin\alpha\,(26.82\,m) = 8.55$

$$\tan\alpha = \frac{8.55}{33.5} \longrightarrow \alpha = 14.318^{\circ}$$

$$B\cos\alpha = \frac{33.5}{.03\,(26.82)} = 41.6319$$

$$B\sin\alpha = \frac{8.55}{.03\,(26.82)} = 10.625$$

$$B = \sqrt{(41.6319)^2 + (10.625)^2} = 42.9664\ Kg.$$

APPENDIX E

Beam Line Septum Magnet-S1B120*

Field Strength	12 kg
Magnet Length	120 inch
Magnet Gap	1.5 inch
Coil Aperture	2.5 inch
Field	1.25 inch
Field Quality	
Coil Turns	8
Copper Conductor Cross Section	1.096-.922/.325 inch
Water Cooling Hole Diameter	.34 /.181 inch
Conductor Corner Radius	.062/.055 inch
Conductor Current	4750 A
Magnet Inductance	
Coil Resistance	.0110 Ω
Voltage Drop	52 V
Power	247 KW
Cooling Water Pressure	200 psi
Number of Water Paths	1/8
Water Flow	1/25 GP
Temperature Rise	34°C
Outside Dimensions	8 inch by 8 inch
Iron Weight	3284 lb.
Copper Weight	325 lb.

*Data taken by Stan Snowdon

041375 – 1400
R.S.

Beam Line Septum Magnet – S1B12.0